PEST CONTROL

Campaign started to eliminate tsetse fly

Male flies are exposed to a short burst of gamma radiation from a cobalt-60 source to inhibit sperm fertility, but the procedure does not impede the fly.

A NEW CAMPAIGN IN Africa to control the deadly tsetse fly, the parasitic carrier of sleeping sickness, has been launched by the Organization of African Unity (OAU).

African sleeping sickness affects as many as 500 000 people, 80 percent of whom eventually die, and the bite of the fly causes more than $4 billion in economic losses annually, according to the International Atomic Energy Agency (IAEA).

The tsetse fly has turned much of the fertile African landscape into an uninhabited "green desert," spreading sleeping sickness—and killing 3 million livestock animals every year. The fly is the carrier of the single-cell parasite, trypanosome, which attacks the blood and nervous system of its victims, causing sleeping sickness in humans and nagana in livestock. The biting tsetse fly transmits it when it seeks a blood meal.

Despite various drastic efforts over the past 100 years to eradicate the tsetse fly, most of the time it has recovered. The tsetse, about the size of a house fly, infests 37 sub-Saharan African countries—32 of them among the 42 most Heavily Indebted Poor Countries (HIPCs) in the world. Much of Africa's best land—particularly in river valleys and moist areas, where the potential for mixed farming is good—lies uncultivated, while tsetse-free areas face collapse from overuse by humans.

The range of the fly is expanding and in some parts of Africa renewed outbreaks of sleeping sickness are killing more people than any other disease.

Some of these native African Zebu cattle in Tanzania are already sick with nagana, the devastating livestock disease spread by the tsetse fly. (Photos: Petr Pavlicek/IAEA)

Zanzibar breakthrough

In 1997, the Tanzanian island of Zanzibar was declared free of the tsetse after conventional methods reduced its numbers and the release of hundreds of thousands of infertile male flies into the wild—sterilized using a nuclear technology—clinched its success. In Burkina Faso in 2001, the Organization of African Unity inaugurated the Pan African Tsetse and Trypanosomosis Eradication Campaign (PATTEC), based on the successful Zanzibar program.

"The impact of the fly is difficult to exaggerate," said John Kabayo, regional coordinator of PATTEC, based in Addis Ababa, Ethiopia. "It is no accident that the concentration of much of the world's most acute poverty is in regions of sub-Saharan Africa infested with it. But Zanzibar was the breakthrough. Now we know how to control it."

In Zanzibar, said Kabayo, the island's Ministry of Agriculture has reported that since the program to control and eradicate the tsetse began, milk production has tripled, local beef production has doubled, and the number of farmers who fertilize crops with manure has multiplied fivefold. Fears that tsetse elimination would have a harmful environmental impact on the island's biodiversity have been unfounded.

Leading global organizations fighting poverty and disease—the Food and Agriculture Organization (FAO) of the United Nations, the World Health Organization (WHO), and the IAEA—are supporting PATTEC. The United Nations Economic and Social Council (ECOSOC), the priority setting body for the world organization, has acknowledged that creating tsetse-free zones will be a valuable step toward reducing rural poverty.

The root of poverty

"Africa is now ready to combat the tsetse fly," said Peter Salema, deputy director of the Vienna-based joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. "It is a root of poverty in sub-Saharan Africa, a devastating problem that has been allowed to fester because there was a perception it could not be solved, and because it is a problem of the rural poor."

He said that although the IAEA is known for its role in the verification of peaceful uses of nuclear power and promoting worldwide nuclear safety, most of its member states do not use nuclear power. In these countries the agency's work focuses on applying nuclear science and technology to development issues affecting health, fresh water, agriculture, and other areas.

The Zanzibar breakthrough—after a joint program between the government of Tanzania, the IAEA, and the FAO—was achieved using the sterile insect technique (SIT), in combination with applying insecticide to the backs of cattle and setting insecticide-impregnated traps to reduce the tsetse population.

The SIT method is a standard tool in the successful control of the Mediterranean fruit fly in Argentina, Chile, Mexico, and

California, and the melon fly in Japan, and it eradicated the New World Screwworm in the United States, Mexico, Central America, and Libya.

The technique introduces hundreds of thousands of sterile male flies into the breeding population of a target region. The sterile males are able to mate and produce sperm, but the eggs in the female do not develop.

The flies are bred in special centers and male flies, after their birth, are exposed to a short burst of gamma radiation from a cobalt-60 source. The radiation is strong enough to inhibit the fertility of the sperm, but does not impede the fly.

The flies are then released from a specially outfitted plane over the target area into the atmosphere. The infertile males compete with fertile flies to mate with females. Once a female tsetse fly mates with an infertile male, however, she stores the sperm in her abdomen and joins them with the five to eight eggs that she will produce over the course of her lifetime.

"SIT achieved what no other means of control had been able to accomplish before," said Salema. "It demonstrated its potential for Africa by cleaning up the last tsetse fly from Zanzibar. Cattle farmers and fruit growers in North and South America have prospered enormously from SIT against the New World Screwworm and the Mediterranean fruit fly. Now it is Africa's turn to use it against the tsetse."

The tsetse infests a region of sub-Saharan Africa that measures about 9 million km^2—nearly one-third of Africa—and almost as big as the United States. Out of a population of 260 million people in this area, 60 million are at risk from sleeping sickness.

Although efforts are under way to promote the use of cattle breeds less susceptible to nagana, the disease transmitted by the tsetse, usually only low productive native breeds of cattle—maintained by drugs to which trypanosome parasites are becoming resistant—can survive in tsetse-infested regions. With many breeds of cattle, when infected, cows abort much of the time, bulls become infertile, and their growth is stunted.

Experts say that the number of cattle in tsetse areas would increase in the absence of the tsetse fly. However, it is expected that there would be more even distribution of livestock—easing overgrazing and soil erosion in current tsetse-free overstocked areas—and a marked shift to more productive breeds. Under PATTEC, tsetse control is accompanied by thorough land use planning to guide environmentally responsible use of natural resources in tsetse-free areas. Raising the increased productivity of livestock and agriculture would reduce pressure on forested and wildlife areas.

In Zanzibar, eradication of the tsetse has allowed the introduction of cross-breed cattle whose production of milk is nine times that of native Zebu species.

No vaccines

Scientists have been unable to develop a vaccine for humans or cattle because once in the blood stream, trypanosomes are able to change the outer protein coat they wear into at least 1000 variants. Drugs that prevent the onset of sleeping sickness and the drugs available to treat it are highly toxic or difficult to administer.

"The solution to the tsetse is within our reach," said Kabayo. "Now Africa has to take full ownership of the campaign, but it will need assistance," he said. "The key will be political perseverance by Africa and securing financial support." He said that PATTEC owes a major debt of thanks to the IAEA, which has fostered its development and encouraged the use of SIT as one of the tools integrated into the process of creating tsetse-free zones.

Major pharmaceutical companies and U.S. foundations are committing funds to assist WHO in combating sleeping sickness and through WHO, PATTEC's public partners have recently been invited by a pharmaceutical company to identify their needs to fight tsetse and nagana.

The impact of the tsetse on livestock, a disadvantage unique to African farmers, is worsening as the fly's range expands and the resistance of the parasite it carries strengthens.

Once considered under control, a resurgence of the tsetse poses a major threat to public health. In some regions of the war-torn Democratic Republic of the Congo, in central Africa, sleeping sickness is killing more people than any other communicable disease, including HIV/AIDS, says the World Health Organization.

Farmers, already marginalized, are being forced to crowd into ever-shrinking and fragile highland regions to escape it, or are driven off their land by the spread of the tsetse and swell the ranks of the homeless in African cities.

In a study funded by the UK Department for International Development (DFID), the researchers estimated that the tsetse fly's annual cost to agriculture in Africa totals $4.5 billion. "One single problem that is uniquely African is the tsetse," said Kabayo. "But it has become so much part of the fabric of Africa there has been complacency towards it."

Freedom from the tsetse would offer the agricultural opportunities to much of sub-Saharan Africa that Zanzibar is enjoying and the possibility for families to own productive livestock and increase their food supply and income.

To combat nagana, the international community has identified the cotton belt in West Africa and the Ethiopian valley system among priority areas where the impact of the tsetse is greatest and intervention will generate major livestock, agricultural, and human development benefits.

No other region in the world suffers the same animal health problem as the tsetse imposes on Africa. In Asia, for example, the World Organization of Animal Health (OIE) estimates that 50 percent of all crop production is carried out by animal power. In sub-Saharan Africa draft power in crop production is 5 to 10 percent.

Because of the tsetse, horses and other beasts of burden are conspicuously absent from the African tsetse fly regions. A UN commissioned study in Zimbabwe found that farmers who were able to use animal traction generated from 25 to 45 percent more income per unit of land and from 140 to 143 percent more per unit of labor than farmers who cultivated by hand.

Pastoralists keep large herds of livestock as an insurance against the impact of the tsetse fly, but overgrazing is damaging fragile environments.

Food production decline

In sub-Saharan Africa, the average amount of food production per person has declined in the last 40 years, said a report delivered in 2001 by UN Secretary General Kofi Annan, at a meeting of the UN Economic and Social Council, in Geneva.

"The world is committed to halving the number of undernourished people by 2015," said Salema, "but without addressing the root causes of low agricultural productivity all other efforts will fail."

Permitting more African farmers to own livestock and maximize their contribution to agricultural activities would have a profound impact on hunger and poverty in the continent, providing them with milk and meat and enhancing crop production—elements of mixed farming that are difficult to achieve in tsetse-infested zones. Even the poorest of the poor, for whom the risk of livestock ownership is too hazardous with the tsetse, would benefit, said Salema.

"Only by refocusing our efforts on rural areas in order to enhance agricultural production, thereby allowing the poorest farmers to earn income, can many other poverty-reduction processes succeed," he declared.

The promise of SIT is that unlike earlier control programs, in conjunction with other control methods, it can establish fly-free areas without need for further control, Salema said.

Nearly 45 000 new cases of sleeping sickness were reported in 1999. Only 3 to 4 million of the more than 60 million people at risk are being screened, and the total number of cases may be as high as 500 000, WHO reported.

In the absence of effective screening "most people with sleeping sickness (an estimated 80 percent) die before they can ever be diagnosed," WHO said. The scale of death from the current epidemic of sleeping sickness is unknown but in some villages in the Democratic Republic of Congo, 90 percent of residents suffer from the disease. At the beginning of the 20th century, millions of people died in an epidemic. Early diagnosis offers a relatively high chance of cure.

There are two distinct forms of sleeping sickness: in central and West Africa, the tsetse fly carries the gambiense strain, and in southern and east Africa it transmits the rhodesiense trypanosome.

Rhodesiense causes an acute infection of the brain that emerges after a few weeks and is easier to detect. Gambiense can infect a person for months, or years, without symptoms while parasites multiply in the bloodstream and lymphatic system.

Vulnerable children

When the parasites cross the blood-brain barrier and invade the central nervous system, there are neurological changes that are often irreversible, particularly for children, who are often the most vulnerable to the disease.

Treatment at this stage must follow the same path and is radical: Melarsoprol, an arsenic and glycol compound, may cause up to 10 percent fatalities; and Eflornithine, a modern alternative, requires a strict and complex regimen of treatment that often makes it unusable.

The current sleeping sickness epidemic in Africa began in the mid-1970s, WHO said. Systematic screening treatment between 1940 and 1960 resulted in the number of cases of sleeping sickness declining to almost zero.

In some provinces in the Democratic Republic of Congo, gambiense is the leading cause of death. In the region of conflict between southern Sudan and northern Angola, which includes the Democratic Republic of Congo, it is estimated that 20 percent of the population is infected.

Many insects invest their security in quantity, producing huge numbers of offspring, some of which will survive. The tsetse fly, however, carries its young to their full larval development before giving birth. The larvae rapidly pupate and adults emerge a month later.

The female mates in the first days of life, and stores sperm in pockets in her abdomen that she releases each time she ovulates. In a life span of three months she produces on average four to six offspring.

While the female is feeding, digesting, resting, and producing larvae, the male is actively trying to mate, a busy pursuit that reduces his life span to about four weeks.

Proportionate to its body size, the tsetse fly has to ingest a massive amount of blood in order to meet its food needs. It is also a poor flyer, lasting only about five minutes on the wing before its energy falls off. It cannot fly long distances. Because of the insect's poor mobility, parasitic infections caused by the tsetse are usually concentrated in small areas.

The fly becomes the host for the trypanosome parasite after feeding on the blood of an infected animal or human. After it is taken up by the fly, the cycle of the parasite in the tsetse takes 12 to 21 days before it can enter a new host. Usually less than 5 percent of tsetse flies carry the parasite, yet even small numbers of infected flies are known to be efficient vectors.

Frequently, parasites block the mouth parts of the fly, reducing the amount of blood it can take up, forcing it to feed more often, and increasing the parasites' chance of infecting more cattle and humans.

There are about 22 species of tsetse fly, divided into three major groups—savannah, riverine, and rainforest—but their concentration in fragmented populations, mostly with only one to three species at any one place, allows targeted intervention.

Making Africa tsetse-free is a daunting undertaking, said Kabayo. "But there's a riddle in Africa that asks how you eat an elephant—and the answer is in small pieces. This is how we will accomplish control of the tsetse, establishing first one fly-free area and then moving on to another."

The valleys of Ethiopia, the cotton belt in West Africa, and a region in southern Africa, starting with the Okavango Delta, will be the initial areas where the control program is to be conducted.

A study of the benefits of removing the tsetse from southern Ethiopia, commissioned by the IAEA and undertaken by the Imperial College of Science and Technology in Great Britain, estimated the return on investment to be between 33 and 43 percent.